ERIC Notebook

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Incidence Measures in Cohort Studies

Cohort studies are longitudinal studies where an exposed and an unexposed group are followed forward in time to find the incidence of the outcome of interest (disease, death, or change in health). Two measures of incidence are cumulative incidence (CI) and incidence rate (IR). These two measures can be further manipulated to provide additional information on the effects of the exposure of interest, such as relative risk, incidence rate ratio, attributable risks, incidence rate differences and attributable risk percent.

CI is defined as the number of new cases divided by the total population-at-risk at the beginning of the follow-up period. The CI measures an individual's risk of developing the outcome of interest.

- CI = new cases / total population-at-risk

The IR is the number of new cases of disease divided by the total person-time-at-risk for the population. Person-time is calculated by the sum total of time all individuals remain in the study without developing the outcome of interest (the total amount of time that the study members are at risk of developing the outcome of interest). Person-time can be measured in days, months, or years, depending on the unit of time that is relevant to the study. The IR measures the rapidity of disease occurrence in the population.

- IR = new cases / person-time-at-risk

Two-by-two tables are generally used to organize the data from a study as shown below.

	Disease	No disease	Total
Exposed	a	b	a+b
Unexposed	c	d	c+d
Total	a+c	b+d	a+b+c+d

Relative risks. The CI measures for the exposed and unexposed groups must be compared in order to find the relative risk (RR) for exposure versus no exposure, or the relative increase or decrease in risk caused by the exposure under study. The RR is defined as the CI in the exposed cohort (the index group) divided by the CI in the unexposed cohort (the reference group). An RR may vary from zero to infinity.

- $RR = CI_{exposed} / CI_{unexposed} = [a / (a+b)] / [c / (c+d)]$

For example, suppose researchers conduct a cohort study and gather the following data on the effects of gasoline fume exposure on respiratory illness among automotive workers.

Study group	Illness	No illness	Total
Exposed	60	140	200
Unexposed	25	175	200
Total	85	315	400

In this study, the CI in the exposed group is 60/200, or 0.30 cases per person (30 cases per 100 people), and the CI in the unexposed group is 25/175, or 0.14 cases per person (14 cases per 100 people). Therefore, the RR is 0.30/0.14, or 2.1. A relative risk of 2.1 implies that the exposed group has 2.1 times the risk of developing respiratory illness as the unexposed group.

Incidence Rate Ratio. When incidence rates (IRs) are computed in a study, the incidence rate ratio (IRR) is the measure that compares the $IR_{exposed}$ to the $IR_{unexposed}$. The incidence rate ratio is defined as the rate of disease occurrence in the exposed cohort (the index group) divided by the rate of disease occurrence in the unexposed cohort (the reference group).

- $IRR = IR_{exposed} / IR_{unexposed}$

An incidence rate ratio measure also shows whether the exposure was preventive, causative, or had no effect on the rate of disease outcome in the exposed population as compared to the unexposed population.

- If in the previous example, the person-time-at-risk that each automotive worker contributed to the study had been recorded then the table might have looked like the following:

Study group	Illness	No illness	Total person-years at risk
Exposed	60	140	175 person-years
Unexposed	25	175	188 person-years
Total	85	315	363 person-years

In this study, the IR in the exposed cohort is 60/175 person-years, or 0.34 cases/person-year. The IR in the unexposed cohort is 25/188 person-years, or 0.13 cases/person-year. The IRR in this study is 0.34/0.13, or 2.6, which is higher than the relative risk calculated above. This IRR reveals that respiratory illness among workers exposed to gasoline fumes is developing at 2.6 times the rate that respiratory illness is developing among workers not exposed to gasoline fumes.

An exposure may be preventive (e.g., vitamin intake) or harmful (e.g., toxic chemical exposure). Assuming there are no other factors that may confound the association, an RR or IRR less than 1 indicates that the risk in the exposed (index) group is less than the risk in the unexposed (reference) group, and therefore, the exposure is preventive. An RR or IRR that equals 1 (the null value) indicates that there is no difference in risk between exposed and unexposed groups. An RR or IRR greater than one indicates that the risk in the exposed is greater than the risk in the unexposed, and, therefore, the exposure is harmful.

The following table may be applied to both relative risks and incidence rate ratios.

RR or IRR	Exposure
<1	Exposure is preventive.
=1	Exposure is neither preventive nor causative.
>1	Exposure is harmful.

The farther away the RR or IRR is from the null value of one, the greater the effect of exposure is on the study group. This is shown in the following diagram.

Attributable risks and incidence rate differences. In order to find the absolute effect of an exposure on disease the attributable risk (AR), or risk difference, must be computed. The attributable risk is the excess risk among the exposed population attributed to exposure. It is defined as the risk in the exposed minus the risk in the unexposed.

- $AR = CI_{exposed} - CI_{unexposed} = a / (a+b) – c / (c+d)$

In the above example of gasoline fume exposure and respiratory illness, the CI in the exposed group was 60/200, or 0.30 cases per person. The CI in the unexposed group was 25/175, or 0.14 cases per person. Therefore, the AR would be (0.30 – 0.14) = 0.16 cases per person, or 16 cases per 100 people. This measure reveals that those exposed to gasoline fumes have an excess risk of 16 cases per 100 persons above the risk among those not exposed to gasoline fumes.

Likewise, the incidence rate difference (IRD) is defined as the difference between the rate of disease outcome in the exposed population minus the rate of disease outcome in the unexposed population.

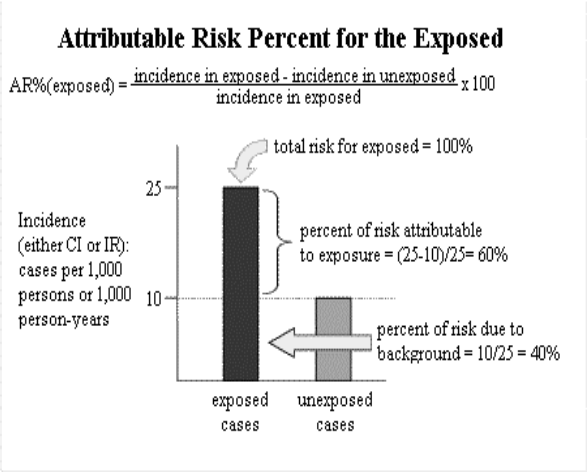
- $IRD = IR_{exposed} - IR_{unexposed}$

In the above example including person-time data, the IR in the exposed cohort was 60/175 person-years, or 0.34 cases/person-year and the IR in the unexposed cohort is 25/188 person-years, or 0.13 cases/person-year. Therefore, the IRD is computed to be (0.34 – 0.13) = 0.11 cases per person-year. This IRD measure reveals that disease is occurring in the exposed group at a rate of 11 cases per 100 person-years above the rate in the unexposed group. This higher rate is attributed to gasoline fume exposure.

Attributable risk percent. The attributable risk percent (AR%) expresses the proportion of disease attributable to exposure in either the exposed (also called "etiologic fraction") or in the total population (also called "population attributable risk").

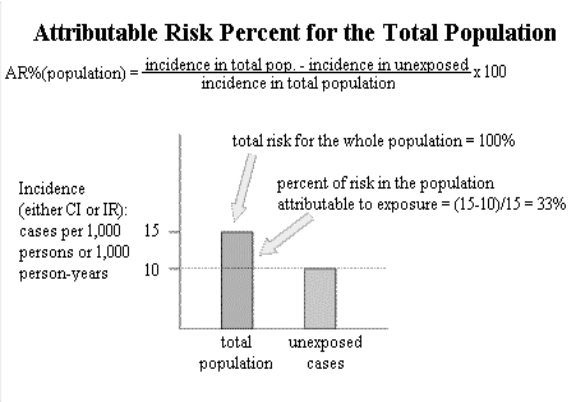
- $\text{AR\% Exposed} = \frac{\text{incidence in exposed - incidence in unexposed}}{\text{incidence in exposed}} \times 100$

AR% (exposed) = the proportion of risk among the exposed attributable to exposure.



- $\text{AR\% Total Population} = \frac{\text{incidence in total pop. - incidence in unexposed}}{\text{incidence in total population}} \times 100$

AR% (total population) = the proportion of risk in the total population attributable to exposure. NOTE: the size of this proportion is directly proportional to the fraction of the total population exposed to the risk factor of interest.



Self-Evaluation

Q 1: Researchers conduct a prospective cohort study to explore the relationship between visual impairment and the risk of injuries from falls among the elderly. A total of 400 visually impaired (VI) persons aged 70 or older are compared against 400 persons of comparable age without VI. Over a 5-year follow-up period, 80 VI persons and 20 non-VI persons have injuries from falls.

a. Construct a 2x2 table from the information above.
b. The incidence attributable to exposure is:
c. The attributable risk percent in the total population is:

Q 2: Researchers conduct a prospective cohort study to explore the relationship between alcohol consumption and the incidence of colon cancer. A total of 4000 men are followed for an average of 10 years; 2000 were moderate alcohol drinkers and 2000 were nondrinkers. A total of 30 incident cases of colon cancer were diagnosed in the moderate drinkers and 15 incident cases were diagnosed in the nondrinkers. (Assume all cases occurred at year 5.)

a. Construct at 2x2 table from the information above.
b. The incidence rate (per 10,000 person-years) of colon cancer among moderate drinkers is:
c. The relative rate of colon cancer is:
d. The attributable risk percent among the exposed is:

Answers

1. a.

Study group	Injuries from falls	no injuries from falls	total
exposed (VI)	80	320	400
unexposed (not VI)	20	380	400
total	100	700	800

b. $CI_{exposed}$ = 80/400 = 0.20 cases/person $CI_{unexposed}$ = 20/400 = 0.05 cases/person AR = 0.20 - 0.05 = 0.15 cases/person
c. $CI_{total\ population}$ = 100/800 = 0.125 cases/person
AR% = [(0.125 - 0.05)/0.125] x 100% = 60%

2. a.

Study group	colon cancer	no colon cancer	total person-years
Alcohol drinkers	30	1970	(30x5+1970x10) = 19,850
Non-drinkers	15	1985	(15x5 + 1985x10)=19,925
Total	45	3955	39775

b. $IR_{exposed}$ = 30/19850 person-years x 10,000 = 15.1 cases/10,000 person-years
c. RR= (30/19850) / (15/19925) = 2.0
d. AR% (exposed) = [(15.1 cases/10,000 p-y) - (7.5 cases/10,000 p-y)] / (15.1 cases/10,000 p-y)] x 100% = 50.3%, i.e. approximately 50% of the cases among the alcohol drinkers are attributable to their consumption of alcohol.

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